regulatory uncertainties to their full operational life. Consequently, the provisions of No. 2613 **(S22.2)** would not apply in this band for non-geostationary mobile-satellite service feeder links in the space-to-Earth direction of transmission.

USA/ /11 ADD

809B **(S5.458B)** The use of the band 6650-7075 MHz (space-to-Earth) by the fixed satellite service is subject to the application of the coordination and notification procedures set forth in MOD Resolution **46**. Emissions from a non-geostationary space station shall not exceed the power flux density levels at the earth's surface as specified in MOD No. Article 28 (**S21.16**. The aggregate of all emissions from non-geostationary satellite networks shall not exceed the power flux-density limit at the geostationary satellite orbit as specified in ADD No. 2631A (**S22.5A**)

Reason:

The application of the coordination and notification procedures set forth in MOD Resolution 46 would be necessary for shared, bi-directional use of the 6650-7075 MHz band by non-geostationary mobile-satellite service feeder links. The power flux-density values at the Earth's surface specified in MOD No. S21.16 for the 6650-7075 MHz band would be necessary to protect terrestrial services. The power flux-density limits specified in ADD No. S22.5A would be necessary to protect space stations at the geostationary satellite orbit. (A separate U.S. document contains proposals for MOD No. S21.16 and ADD No. S22.5A. No. S21.16, Table AR28 recommended by the VGE, tabulates the pfd limits at the Earth's surface which correspond to limits contained in Article 28 of the current Radio Regulations. ADD No. S22.5A would correspond to ADD No. 2631A to the current Radio Regulations.)

USA/ /12
MOD

GHz
10.7-12.75

Allocation To Services		
Region 1	Region 2	Region 3
10.7-10.95 ~~**11.7**~~ FIXED FIXED-SATELLITE (space-to-Earth) MOD 792A (Earth-to-space) 792B MOD 835 MOBILE except aeronautical mobile 792C	**10.7-10.95** ~~**11.7**~~ FIXED FIXED-SATELLITE (space-to-Earth) MOD 792A (Earth-to-space) 792B MOBILE except aeronautical mobile 792C	
10.95-11.2 FIXED FIXED-SATELLITE (space-to-Earth) ~~792A~~ (Earth-to-space) MOD 835 MOBILE except aeronautical mobile	**10.95 - 11.2** FIXED FIXED-SATELLITE (space-to-Earth) ~~792A~~ MOBILE except aeronautical mobile	

11.2-11.45 FIXED FIXED-SATELLITE (space-to-Earth) MOD 792A (Earth-to-space) MOD 835 792B MOBILE except aeronautical mobile 792C	11.2 - 11.45 FIXED FIXED-SATELLITE (space-to-Earth) MOD 792A (Earth-to-space) 792B MOBILE except aeronautical mobile 792C
11.45-11.7 FIXED FIXED-SATELLITE (space-to-Earth) ~~792A~~ (Earth-to-space) MOD 835 MOBILE except aeronautical mobile	11.45 - 11.7 FIXED FIXED-SATELLITE (space-to-Earth) ~~792A~~ MOBILE except aeronautical mobile

Reason:

Revisions to the Table in the 10.7-10.95 and 11.2-11.45 GHz bands are necessary to allocate spectrum specifically for feeder links in the 8 to 16 GHz frequency range to support current and future requirements of mobile-satellite services provided from non-geostationary satellite networks. The CPM-95 indicated that studies have shown that bi-directional spectrum sharing between the geostationary fixed-satellite service and non-geostationary mobile-satellite service feeder link networks is technically feasible given careful site selection and gateway antenna sizing to accommodate systems operating in accordance with Appendix 30B **(S30B)** Modification of No. 792A **(S5.441)** and MOD No. 835 **(S5.484)**, suppression of No. 792A **(S5.441)** in the 10.95-11.2 GHz and 11.45-11.7 GHz bands, and addition of Nos. 792B **(S5.441)** and 792C **(S5.441B)** is therefore consequential. A potential paired band in the space-to-Earth direction of transmission could be 12.75-13.25 GHz.

USA/ /13 ADD

792B (S5.441A) The use of the bands 10.7-10.95 GHz (Earth-to-space) and 11.2-11.45 GHz (Earth-to-space) by the fixed-satellite service is limited to feeder links for non-geostationary satellite networks of the mobile-satellite service except as provided by MOD No. 835 **(S5.484)**. The provisions of No.2613 **(S22.2)** do not apply.

Reason:

The CPM-95 has indicated that bi-directional sharing between non-geostationary mobile-satellite service feeder links in the Earth-to-space direction and geostationary fixed-satellite service networks operating in the space-to-Earth direction in the 10.7-10.95 GHz and 11.2-11.45 GHz bands is technically feasible. Therefore, ADD No.792B **(S5.441A)** allocates the 10.7-10.95 GHz and 11.2-11.45 GHz bands, in the Earth-to-space direction of transmission, to the fixed-satellite service and limits the allocation to non-geostationary mobile-satellite service feeder links with the exception of those feeder links for the broadcasting-satellite service operating in accordance with MOD No. 835 **(S5.484)**. The CPM-95 has also indicated that procedural revisions would be necessary to provide a regulatory base which would permit the orderly operation of non-geostationary mobile-satellite service feeder links without any regulatory uncertainties to their full operational life. Consequently, the provisions of No. 2613 **(S22.2)** would not apply in this band for non-geostationary mobile-satellite service feeder links in the Earth-to-space direction of transmission.

USA/ /14 ADD

792C (S5.441B) The use of the bands 10.7-10.95 GHz (Earth-to-space), and 11.2-11.45 GHz (Earth-to-space) by the fixed-satellite service is subject to the application of the coordination and notification procedures set forth in MOD Resolution **46**.

Reason:

The application of the coordination and notification procedures set forth in MOD Resolution **46** would be necessary for shared, bi-directional use of the 10.7-10.95 GHz and 11.2-11.45 GHz bands by non-geostationary mobile-satellite service feeder links.

USA/ /15 MOD

835 **(S5.484)** In Region 1, the ~~use of the band~~ 10.7-11.7 GHz ~~by~~ band may also be used by the fixed-satellite service (Earth-to-space) ~~is limited to~~ for feeder links for the broadcasting-satellite service.

Reason:

MOD No.835 (S5.484) would allow for continued use of the 10.7-10.95 GHz and 11.2-11.45 GHz bands by the fixed-satellite service for feeder links for the broadcasting-satellite service in Region 1.

USA/ /16
MOD

GHz
12.75-14.3

Allocation To Services		
Region 1	Region 2	Region 3
12.75-13.25 FIXED FIXED-SATELLITE (Earth-to-space) MOD 792A (space-to-Earth) 809C MOBILE Space Research (deep space) (space-to-Earth) 809D		

Reason:

Revisions to the Table in the 12.75-13.25 GHz band are necessary to allocate spectrum specifically for feeder links in the 8 to 16 GHz frequency range to support current and future requirements of mobile-satellite services provided from non-geostationary satellite networks. The CPM-95 indicated that studies have shown that bi-directional spectrum sharing between the geostationary fixed-satellite service and non-geostationary mobile-satellite service feeder link networks is technically feasible given careful site selection and antenna sizing. Modification of No. 792A **(S5.441)** and addition of Nos. 809C **(S5.458C)** and 809D **(S5.458D)** is therefore consequential.

Potentially, the paired bands in the Earth-to-space direction of transmission could be 10.7-10.95 GHz and 11.2-11.45 GHz.

USA/ /17 ADD

809C (S5.458C)

The use of the band 12.75-13.25 GHz (space-to-Earth) by the fixed-satellite service is limited to feeder links for non-geostationary satellite networks of the mobile-satellite service. The provisions of No. 2613 **(S22.2)** do not apply.

Reason:

The CPM-95 has indicated that bi-directional sharing between non-geostationary mobile-satellite service feeder links in the space-to-Earth direction and geostationary fixed-satellite service networks operating in the Earth-to-space direction in the 12.75-13.25 GHz band is technically feasible. Therefore, ADD No. 809C **(S5.458C)** allocates the 12.75-13.25 GHz band, in the space-to-Earth direction of transmission, to the fixed-satellite service and limits the allocation to non-geostationary mobile-satellite service feeder links. The CPM-95 has also indicated that procedural revisions would be necessary to provide a regulatory base which would permit the orderly operation of non-geostationary mobile-satellite service feeder links without any regulatory uncertainties to their full operational life. Consequently, the provisions of No. 2613 **(S22.2)** would not apply in this band for non-geostationary mobile-satellite service feeder links in the space-to-Earth direction of transmission.

USA/ /18 ADD

809D (S5.458D) The use of the band 12.75-13.25 GHz (space-to-Earth) by the fixed satellite service is subject to the application of the coordination and notification procedures set forth in MOD Resolution **46**. Emissions from a non-geostationary space station shall not exceed the power flux-density at the Earth's surface as specified in MOD No. Article 28 **(S21.16)** for the 12.75-13.25 GHz band. Non-geostationary satellite networks shall not exceed the power flux-density limit at the geostationary-satellite orbit as specified in ADD No. 2631A **(S22.5A)**.

Reason:

The application of the coordination and notification procedures set forth in MOD Resolution **46** would be necessary for shared, bi-directional use of the 12.75-13.25 GHz band by non-geostationary mobile-satellite service feeder links. Should the power flux-density values at the Earth's surface specified in MOD No. Article 28 **(S21.16)** for the 12.75-13.25 GHz band be exceeded by a non-geostationary feeder link network, coordination between that non-geostationary satellite network (space-to-Earth) and terrestrial services would be triggered. The power flux-density limits specified in ADD No.2631A **(S22.5A)** would be necessary to protect space stations at the geostationary satellite orbit.

GHz
15.35-17.7

USA/ /19
MOD

Allocation To Services		
Region 1	Region 2	Region 3
15.4-~~15.7~~15.45 AERONAUTICAL RADIONAVIGATION MOD 733 MOD 797		
15.45-15.65 AERONAUTICAL RADIONAVIGATION 797E FIXED-SATELLITE (Earth-to-space) 797F (space-to-Earth) 797G ~~733 797~~ 797H 797I		
15.65-15.7 AERONAUTICAL RADIONAVIGATION MOD 733 MOD 797		

Reason:

Revisions to the Table in the 15.4-15.7 GHz band are necessary to allocate spectrum specifically for feeder links in the 8 to 16 GHz frequency range to support current and immediate requirements of mobile-satellite services provided from non-geostationary satellite networks. The CPM-95 indicated that the feasibility of sharing in this band in either the Earth-to-space or space-to-Earth direction of transmission depends on the nature of use under No. 797 (S5.445). The CPM-95 did not, however, identify current use of the 15.4-15.7 GHz band by the fixed-satellite and inter-satellite services used in conjunction with the aeronautical radionavigation service and/or with the aeronautical mobile (R) services, in accordance with No. 797 (S5.445), and indicated that no sharing studies were conducted to assess the feasibility of sharing between these services and non-geostationary satellite networks. The CPM-95 also did not identify use of the 15.4-15.7 GHz band by the aeronautical mobile (R) service, in accordance with No. 733 (S5.367). Modification of Nos. 733 (S5.367) and 797 (S5.445) would therefore be necessary to accommodate non-geostationary mobile-satellite service feeder links in the 15.45-15.65 GHz band. Addition of

Nos. 797E (S5.447C), 797F (S5.447D), 797G (S5.447E), 797H (S5.447F) and 797I (S5.447G) is also consequential. As indicated by the CPM-95, a potential paired band in the space-to-Earth direction of transmission could be 6650-7075 GHz and, in the Earth-to-space direction, the 19.4-19.7 GHz band.

USA/ /20 ADD

797E (S5.447C) The average eirp radiated by a station in the radionavigation service shall not exceed 42 dBW. This value shall apply subject to review by the ITU-R and until it is changed by a future competent World Radiocommunication Conference.

Reason:

The eirp limit on the radionavigation service is necessary to prevent the radionavigation service from interfering with fixed-satellite service receivers operating in the band. See ANNEX 2 for supporting technical explanation.

USA/ /21 ADD

797F (S5.447D) Use of the band 15.45-15.65 GHz by the fixed-satellite service (Earth-to-space) is limited to feeder links for non-geostationary satellite systems of the mobile-satellite service. The provisions of No. **2613** (S22.2) do not apply. For elevation angles equal to or less than 20 degrees, the eirp density over the necessary bandwidth of any emission from an earth station in the fixed-satellite service (Earth-to-space) shall be at least 66.2 dB(W/MHz) for emission bandwidths less than or equal to 3 MHz. For emission bandwidths greater than 3 MHz, the eirp shall be at least 71 dBW. For elevation angles greater than 20 degrees, the eirp density and eirp values can be reduced respectively by 5 dB.

Reason:

The CPM-95 has indicated that co-directional and bi-directional operation of non-geostationary mobile-satellite service feeder links in the 15.4-15.7 GHz band depends on the nature of use under No. 797 (S5.445). MOD No. 797 (S5.445) applies to the 15.4-15.45 GHz and 15.65-15.7 GHz segments in the 15.4-15.7 GHz band. ADD No. 797F (S5.447D) therefore allocates the 15.45-15.65 GHz band in this specific direction of transmission to the fixed-satellite service and limits the

allocation to non-geostationary mobile-satellite service feeder links. The CPM-95 has also indicated that procedural revisions would be necessary to provide a regulatory base which would permit the orderly operation of non-geostationary mobile-satellite service feeder links without any regulatory uncertainties to their full operational life. Consequently, the provisions of No. 2613 (S22.2) would not apply in this band for non-geostationary mobile-satellite service feeder links in the Earth-to-space or space-to-Earth directions of transmission. The minimum eirp on the earth station transmitter is necessary for the satellite receiver to overcome interference from emissions from aeronautical radionavigation transmissions. See ANNEX 2 for supporting technical explanation.

USA/ /22 ADD

797G (S5.447E) Use of the band 15.45-15.65 GHz by the fixed-satellite service (space-to-Earth) is limited to feeder links for non-geostationary satellite systems of the mobile-satellite service. The provisions of No. **2613** (S22.2) do not apply to the fixed-satellite service (space-to-Earth) in this band. Emissions from a non-geostationary space station shall not exceed the power flux-density levels at the Earth's surface as specified in MOD No. **S21.16** for the band 15.45-15.65 GHz. This value shall apply subject to review by the ITU-R and until it is changed by a future competent World Radiocommunication Conference.

Reason:

The CPM-95 has indicated that co-directional and bi-directional operation of non-geostationary mobile-satellite service feeder links in the 15.4-15.7 GHz band depends on the nature of use under No. 797 (S5.445). MOD No. 797 (S5.445) applies to the 15.4-15.45 GHz and 15.65-15.7 GHz segments in the 15.4-15.7 GHz band. ADD No. 797G (S5.447E) therefore allocates the 15.45-15.65 GHz band in this specific direction of transmission to the fixed-satellite service and limits the allocation to non-geostationary mobile-satellite service feeder links. The CPM-95 has also indicated that procedural revisions would be necessary to provide a regulatory base which would permit the orderly operation of non-geostationary mobile-satellite service feeder links without any regulatory uncertainties to their full operational life. Consequently, the provisions of No. 2613 (S22.2) would not apply in this band for non-geostationary mobile-satellite service feeder links feeder links in the space-to-Earth or Earth-to-space directions of transmission. The power flux-density values at the Earth's

surface specified in MOD No. S21.16 for the 15.45-15.65 GHz band would be necessary to protect aeronautical radionavigation receivers. See ANNEX 2 for supporting technical explanation. (See proposals for MOD No. S21.16. No. S21.16, Table AR28 recommended by the VGE, tabulates the pfd limits at the Earth's surface which correspond to limits contained in Article 28 of the current Radio Regulations.)

USA/ /23 ADD

797H (S5.447F) Use of the band 15.45-15.65 GHz by the fixed-satellite service (Earth-to-space and space-to-Earth) is subject to the application of the coordination and notification procedures set forth in MOD Resolution **46**.

Reason:

The application of the coordination and notification procedures set forth in MOD Resolution 46 would be necessary for shared use of the 15.45-15.65 GHz band by non-geostationary mobile-satellite service feeder links.

USA/ /24 ADD

797I (S5.447G) In making assignments to space stations of the fixed satellite service in the 15.45-15.65 GHz band, administrations shall take all practicable steps to protect the radio astronomy service operating in the band 15.35-15.4 GHz from harmful interference from unwanted emissions.

Reason:

ADD No. 797I (S5.447G) would protect radio astronomy operations in the band 15.35-15.4 GHz.

GHz

18.8-22.21

USA/ /25
MOD

Allocation To Services		
Region 1	Region 2	Region 3
18.8-<u>19.3</u> ~~19.7~~ FIXED FIXED-SATELLITE (space-to-Earth) MOBILE		
<u>19.3-19.4</u> FIXED FIXED-SATELLITE (space-to-Earth) <u>872A</u> MOBILE <u>872B</u>		
~~18.8~~ <u>19.4</u>-19.7 FIXED FIXED-SATELLITE (space-to-Earth) <u>872A</u> <u>(Earth-to-space)872C</u> MOBILE <u>872B</u> <u>872D</u>		

Reason:

Revisions to the Table in the 19.3-19.7 GHz band in the space-to-Earth direction of transmission are necessary to allocate spectrum specifically for feeder links in the 16 to 30 GHz frequency range to support current and immediate requirements of mobile-satellite services provided from non-geostationary satellite networks. The CPM-95 indicated that studies have shown that co-directional spectrum sharing between the geostationary fixed-satellite service and non-geostationary mobile-satellite service feeder link networks is technically feasible. Addition of Nos. 872A **(S5.523A)** and 872B **(S5.523B)** is therefore consequential. A potential paired band in the Earth-to-space direction of transmission could be 29.1-29.5 GHz. Revisions to the Table in the 19.4-19.7 GHz band in the Earth-to-space direction of transmission are necessary to allocate spectrum specifically for feeder links in the 16 to 30 GHz frequency range to support future requirements of mobile-satellite services provided from non-geostationary satellite

networks. The CPM-95 also has indicated non-geostationary mobile-satellite service feeder links could share spectrum in a bi-directional mode either with other non-geostationary mobile-satellite service feeder links or alternatively with geostationary fixed-satellite service networks in the 19.4-19.7 GHz band. It noted further that such use should be paired with a frequency band below 17.7 GHz. A potential paired band in the space-to-Earth direction of transmission could be 15.4-15.7 GHz. Addition of Nos. 872C **(S5.523C)** and 872D **(S5.523D)** is therefore also consequential.

Note: Proposed footnote Nos. 872A, 872B, 872C, 872D are simular to proposed footnote Nos. 873H and 873I found in other U.S. proposal documents. The final footnote for this frequency band should reflect all modifications adopted by the WRC.

USA/ /26 ADD

872A (S5.523A) The band 19.3-19.7 GHz (space-to-Earth) may also be used by the fixed-satellite service for feeder links for non-geostationary satellite systems in the mobile-satellite service. The provisions of No.2613 **(S22.2)** do not apply.

Reason:

The CPM-95 has indicated that co-directional sharing between non-geostationary mobile-satellite service feeder links in the space-to-Earth direction and geostationary fixed-satellite service networks operating in the space-to-Earth direction in the 19.3-19.7 GHz band is technically feasible. Therefore, ADD No. 872A **(S5.523A)** allocates the band 19.3-19.7 GHz for use by the fixed-satellite service for feeder links for the non-geostationary mobile-satellite service in the space-to-Earth direction of transmission. The CPM-95 has also indicated that procedural revisions would be necessary to provide a regulatory base which would permit the orderly operation of non-geostationary mobile-satellite service feeder links without any regulatory uncertainties to their full operational life. Consequently, the provisions of No. 2613 **(S22.2)** would not apply in this band for non-geostationary mobile-satellite service feeder links in the space-to-Earth or Earth-to-space directions of transmission.

USA/ /27 ADD

872B (S5.523B) The use of the band 19.3-19.7 GHz (space-to-Earth) by the fixed-satellite service is subject to the application of the coordination and

notification procedures set forth in MOD Resolution **46**. Emissions from a non-geostationary space station shall not exceed the power flux-density levels at the Earth's surface as specified in MOD Article 28 **(S21.16)**.

Reason:

The application of the coordination and notification procedures set forth in MOD Resolution **46** would be necessary for shared use of the 19.3-19.7 GHz band by non-geostationary mobile-satellite service feeder links. Should the power flux-density values at the Earth's surface specified in MOD No.Article 28 **(S21.16)** for the 19.3-19.7 GHz band be exceeded by a non-geostationary feeder link network, coordination between that non-geostationary satellite network (space-to-Earth) and terrestrial services would be triggered. The power flux-density limits specified in ADD No. 2631A **(S22.5A)** would be necessary to protect space stations at the geostationary satellite orbit.

USA/ /28 ADD

872C **(S5.523C)** The use of the band 19.4-19.7 GHz (Earth-to-space) by the fixed satellite service is limited to feeder links for non-geostationary satellite systems in the mobile-satellite service. The provisions of No. 2613 **(S22.2)** do not apply.

Reason:

The CPM-95 has indicated non-geostationary mobile-satellite service feeder links could share spectrum in a bi-directional mode either with other non-geostationary mobile-satellite service feeder links or alternatively with geostationary fixed-satellite service networks in the 19.4-19.7 GHz band. Therefore, ADD No. 872C **(S5.523C)** allocates the 19.4-19.7 GHz band, in the Earth-to-space direction of transmission, to the fixed-satellite service and limits the allocation to non-geostationary mobile-satellite service feeder links. The CPM-95 has also indicated that procedural revisions would be necessary to provide a regulatory base which would permit the orderly operation of non-geostationary mobile-satellite service feeder links without any regulatory uncertainties to their full operational life. Consequently, No. 2613 **(S22.2)** would not apply in this band for non-geostationary mobile-satellite service feeder links in the Earth-to-space or space-to-Earth directions of transmission.

USA/ /29 ADD

872D S5.523D <u>The use of the band 19.4-19.7 GHz (Earth-to-space) by the fixed satellite service is subject to the application of the coordination and notification procedures set forth in MOD Resolution **46**.</u>

<u>Reason:</u>

The application of the coordination and notification procedures set forth in MOD Resolution **46** would be necessary for shared, bi-directional use of the 19.4-19.7 GHz band by non-geostationary mobile-satellite service feeder links.

USA/ /30
MOD

GHz
25.5-29.9

Allocation To Services		
Region 1	Region 2	Region 3
28.5 - <u>29.1</u> ~~29.5~~ FIXED FIXED-SATELLITE (Earth-to-space) 882D MOBILE Earth Exploration-Satellite (Earth-to-space) 882C 882B		
~~28.5~~ <u>29.1</u> - 29.5 FIXED FIXED-SATELLITE (Earth-to-space) 882D <u>882H</u> MOBILE Earth Exploration-Satellite (Earth-to-space) 882C 882B <u>882I</u>		

<u>Reason:</u>

Revisions to the Table in the 28.5-29.5 GHz band are necessary to allocate spectrum specifically for feeder links in the 16 to 30 GHz frequency range to support current and immediate requirements of mobile-satellite services provided from

non-geostationary satellite networks. The CPM-95 indicated that studies have shown that co-directional spectrum sharing between the geostationary fixed-satellite service and non-geostationary mobile-satellite service feeder link networks is technically feasible. Addition of Nos. 882H **(S5.542A)** and 882I **(S5.542B)** is therefore consequential. A potential paired band in the space-to-Earth direction of transmission could be 19.3-19.7 GHz.

USA/ /31 ADD

882H (S5.542A) The band 29.1-29.5 GHz (Earth-to-space) may also be used by the fixed-satellite service for feeder links for non-geostationary satellite networks of the mobile-satellite service. The provisions of No. 2613 **(S22.2)** do not apply.

Reason:

The CPM-95 has indicated that co-directional sharing between non-geostationary mobile-satellite service feeder links and geostationary fixed-satellite service networks in the 27.5-29.5 GHz band is technically feasible. Therefore, ADD No. 882H **(S5.542A)** allocates the band 29.1-29.5 GHz for use by the fixed-satellite service for feeder links for the non-geostationary mobile-satellite service in the Earth-to-space direction of transmission. The CPM-95 has also indicated that procedural revisions would be necessary to provide a regulatory base which would permit the orderly operation of non-geostationary mobile-satellite service feeder links without any regulatory uncertainties to their full operational life. Consequently, the provisions of No. 2613 (**S22.2**) would not apply in this band for non-geostationary mobile-satellite service feeder links in the Earth-to-space direction of transmission.

USA/ /32 ADD

882I (S5.542B) The use of the band 29.1-29.5 GHz (Earth-to-space) by the fixed-satellite service is subject to the application of the coordination and notification procedures set forth in MOD Resolution **46**.

Reason:

The application of the coordination and notification procedures set forth in MOD Resolution **46** would be necessary for shared, co-directional use of the 29.1-29.5 GHz band by non-geostationary mobile-satellite service feeder links.

USA/ /33 ADD

Annex 1

RESOLUTION No. XXX (WRC-95)

Sharing Studies Concerning the Use
of the Bands 5090-5150 MHz and 5150-5250 MHz for Feeder Links by
the non-Geostationary Mobile-Satellite Service (Earth-to-space)

The World Administrative Radio Conference (Geneva, 1995),

considering

a) that agenda item 3(d) of this Conference requested the consideration, inter alia, of an allocation of frequency bands for feeder links for the mobile-satellite service;

b) that the band 5000-5250 MHz is allocated to the aeronautical radionavigation service in all three ITU Regions;

c) that Annex 10 to the International Civil Aviation Convention (April 1985), Ammendment 69, November 1993, only contains a requirement for MLS operations in accordance with the channelization plan in 5031 - 5090.7 MHz; and

d) that there is a need to determine the operational and technical means to facilitate sharing between feeder links for the mobile-satellite service (Earth-to-space) and the aeronautical radionavigation and associated safety related systems in the bands 5090-5150 MHz and 5150-5250 MHz;

resolves

1. that studies be undertaken by the ITU-R to develop the operational and technical measures that would facilitate sharing between the services mentioned in d);

2. that the International Civil Aviation Organization (ICAO) be invited to participate in these sharing studies;

invites

1. the ITU-R to study, as a matter of urgency, the technical and operational issues relating to the sharing of these bands

between the aeronautical radionavigation service and associated safety related systems and feeder links for the mobile-satellite service (Earth-to-space);

2. administrations to participate actively in such studies by sending contributions to the ITU-R relating to the aforementioned studies;

3. the ITU-R to bring the results of these studies to the attention of the next competent world radio communication conference;

instructs the Secretary-General

to bring this Resolution to the attention of ICAO.

Reason:

To ensure that the necessary sharing studies are undertaken by the ITU-R.

ANNEX 2

SHARING CONSIDERATIONS FOR LINKS FOR THE
MOBILE-SATELLITE SERVICE IN
THE 15.4-15.7 GHZ BAND

1. **INTRODUCTION:**

In Table 15 of the CPM95 Report, the band 15.4-15.7 GHz is shown as a possible band for MSS feeder links in either or both the space-to-Earth and Earth-to-space directions. This band is allocated to the Aeronautical Radionavigation Service (ARNS) on a primary basis with FSS allowed when used in conjunction with the ARNS under Article 14 provisions. The notes in Table 15 indicate that further study is needed to assess the sharing situation. In section 3.7.2 of the CPM95 Report, several systems are identified that operate in this band. These include the land and ship based radars whose characteristics are shown in Table 1.

Table 1 Characteristics Surface Based Radar System

Transmitter Parameters			
Frequency(GHz):	15.65-16.4	Antenna Gain(dBi):	43
Emission Bandwidth(MHz):	20	PRF(Hz):	8,192
Peak e.i.r.p.(dBW):	86	Pulse Length(ms):	0.04
Peak TX Power(kW):	20M	Duty Cycle(%):	0.0328
Receiver Parameters			
Antenna Gain(dBi):	43		
Typical Noise Figure(dB):	6.2 to 6.9		
Typical Noise Temperature(^{0}K):	920 to 1,130		
Typical G/T (dB);	12.5 to 13.4		

Additionally: there are mobile and transportable, land and shipborne aircraft landing systems (ALS); the space shuttle landing system (MSBLS); and airborne, multipurpose radionavigation/radiolocation/weather radars (MPR). Information on these systems is shown in Table 2. The information in these tables was transmitted to the CPM95 from Task Group 8-3, but was not included in the CPM95 Report.

Table 2 Characteristics of Other Systems			
Transmitter Parameters			
System	ALS	MSBLS	MPR
Frequency(GHz):	15.4-15.7	15.4-15.7	15.4-15.7
Emission Bandwidth(MHz):	2,5,or 18	4.4 or 5	2.55
Peak e.i.r.p.(dBW):	58.4 to 71	64.4	70
Antenna Gain(dBi):	25 to 32	31	30
PRF(Hz)	3,334	1,000	800
Pulse Length(ms):	0.3 to 0.35	0.3	1.35 to 1.9
Duty Cycle(%):	0.1 to 0.117	0.03	0.108 to 0.152
Receiver Parameters			
Antenna Gain(dBi):	4-8	8	30
Typical Noise Figure(dB):	8	7	7
Typical Noise Temperature(°K):	1,500	1,100	1,100
Typical G/T (dB);	-23.8 to -27.8 -22.4	-1	

2. POWER FLUX DENSITY (pfd) LIMITS FOR SATELLITE EMISSIONS IN THE SPACE-TO-EARTH DIRECTION

2.1 Analysis

Power flux density limits are an effective method for allowing the sharing of services without requiring coordination. The general expression for the calculation of a pfd limit for this case is

$$pfd \leq -217.6 + 10 \log B - 20 \log l - G/T + I/N \quad (dB(W/m^2/B)) \qquad (1)$$

where: B - bandwidth in Hz
l - wave length in meters
G/T - antenna gain/noise temperature in dB
I/N - allowable interference/noise in dB

Since these systems operate in the ARNS and may be considered as "Safety Service" systems, the protection requirements may be more severe than for other services. Assuming an I/N limit of -10 db, the solution of equation (1) for the radar parameters given in Table 1 results in a pfd limit of -170.3(-170) $dB(W/m^2/4kHz)$. Solution of equation (1) for the systems parameters given in Table 2 results in pfd limits of -133.5(-134) $dB(W/m^2/4kHz)$ for the ALS, -134.9(-135) $dB(W/m^2/4kHz)$ for the MSBLS, and -156.3(-157) $dB(W/m^2/4kHz)$ for the MPR. Since the emission bandwidths of these system are greater than one MHz and they operate above 15 GHz, the pfd's should be expressed as -146 $dB(W/m^2/MHz)$ for surface based radars, -110 $dB(W/m^2/MHz)$ for ALS, -111 $dB(W/m^2/MHz)$ for MSBLS , and -133 $dB(W/m^2/MHz)$ for MPR. It is noted that the values of -110 to 111 $dB(W/m^2/MHz)$ is in the range given in No. 2576 for the 17.7-19.7 GHz band.

2.2 Summary

For co-frequency operation of mobile-satellite feeder links (space-to-Earth) with the aeronautical radionavigation service in the band 15.4-15.7 GHz, the following pfd limits at the surface of the Earth for any angle of arrival need to be imposed on the satellite emissions; -146 dB(W/m^2/MHz) for surface based radars, -133 dB(W/m^2/MHz) for airborne radars, and -111 dB(W/m^2/MHz) for aircraft landing systems.

3.0 MINIMUM FEEDER LINK EARTH STATION E.I.R.P.'S

3.1 General

Minimum Earth station e.i.r.p.'s, along with maximum e.i.r.p.'s for an interfering source is an effective method for allowing the sharing of services without requiring coordination.

Task Group 4-4 studied the interference from radars into digital carriers. Measurements were made over a wide range of pulse repetition frequencies (PRF),(1 kHz to 100 kHz) and duty cycles (d),(0.01% to 100%) for the radar and data rates from 2Mb/s to 45 Mb/s for 3/4 rate forward error correction (FEC) coded QPSK digital carriers operating at a bit error rate (BER) of 1:10^6. An empirical equation was developed from the measurement data which can be used to relate the peak pulsed radar e.i.r.p.(E_P) to an equivalent e.i.r.p.(E_{EQ}), i.e., an e.i.r.p. which would cause the same level of interference. (See Recommendation ITU-R S.1068) The actual average e.i.r.p.(E_{AVE}) is equal to the peak e.i.r.p. times the duty cycle. Under these conditions the empirical equation is;

$$E_{EQ} = E_P - 15 \log[1 + 0.5(PRF/d)] \quad \text{(dBW)} \quad (2)$$

where PRF is in kHz and d is in percent.

Since the pulse width (PW) is equal to (PRF/d), equation (1) can be expressed as;

$$E_{EQ}/E_P = - 15 \log[1 + 5/PW] \quad \text{(dB)} \quad (3)$$

where (PW) is in microseconds. These equations apply when the bandwidth of the radar pulse is equal to or less that the necessary bandwidth of the digital carrier. For the case of a interference from a continuous carrier, the carrier-to-interference (C/I) ratio for a 1:10^6 BER was about 9 dB. This (C/I) is for the condition where interference from other sources is not significant. Since the percent of time that a terrestrial station is operating and the -3 dB contour of its antenna is in conjunction with a satellite is very low, it is assumed that a C/I of 9 db can be tolerated for this small percent of time.

3.2 Geostationary Satellite Case

For the case where the feeder link earth station operates with a geostationary satellite, the minimum e.i.r.p. (E_{MIN}) can be expressed as:

$$E_{MIN} \geq E_P - 15 \log[1 + 5/PW] + 9 \quad \text{(dBW)} \quad (4)$$

Solution of equation (4) for the parameters given in tables 1 and 2 is shown in table 3.

Table 3 Minimum Earth Station e.i.r.p. (GSO case)

System	SBR	ALS_H	ALS_L	MSBLS	MPR
E_P (dBW)	86	71	58.4	64.4	70
d (%)	0.0328	0.117	0.1	0.03	0.152
E_{AV} (dBW)	51.1	41.7	28.4	29.2	41.8
PW (ms)	0.04	0.35	0.3	0.3	1.9
E_{EQ}/E_P (dB)	-31.5	-17.8	-18.7	-18.7	-8.4
E_{MIN} (dBW)	63.5	62.2	48.7	54.7	70.6

The results in table 3 are for feeder links which use FDMA and use QPSK with 3/4 rate FEC coding. Previous measurements have indicated that about a 3 dB higher e.i.r.p. will be needed for uncoded QPSK modulation.

When the minimum bandwidth of the radar pulse is greater than the necessary bandwidth of the digital carrier, the minimum e.i.r.p.'s can be expressed as e.i.r.p. densities. The minimum bandwidth of the pulse corresponds to longest pulse duration. The minimum bandwidth of the ALS and MSBLS is about three MHz, the reciprocal of the pulse duration from table 2. For the MPR the bandwidth is about 500 kHz and for the surface based radars is about 25 MHz.

3.3 Non-Geostationary Case

Two other factors are needed to determine the feeder link earth station e.i.r.p. required to overcome the terrestrial interference,i.e., the space loss ratio and satellite antenna gain ratio between the interference path and the desired path. These ratios are near unity for the geostationary case. The (E_{MIN}) for FDMA accessing with QPSK 3/4 rate FEC coding can be expressed as:

$$E_{MIN} \geq E_P - 15 \log[1 + 5/d] + 6 + 20 \log (d_1/d_2) - G_1 + G_2 \quad \text{(dBW)} \quad (5)$$

where: d_1 - feeder link station to satellite distance - km
d_2 - terrestrial station to satellite distance - km
G_1 - satellite antenna gain to feeder link station - dB
G_2 - satellite antenna gain to terrestrial station - dB

For low satellite antenna gains, the (G_1) and (G_2) will be nearly equal. For higher gains and particularly for tracking satellite antennas, (G_1) will equal or exceed (G_2). Thus a nearly worst case is when (G_1) and (G_2) are equal.

In general, for circular orbits, the satellite will spend more time with low angles of arrival to a point on the Earth than with high angles of arrival. Thus, (d_1/d_2) will be greater than one for more than 50 percent of the time. The value of (d_1) is equal to;

$$d_1 = [2r(r+h)\{1 - \cos[\cos^{-1}(r \cos a/(r+h)) - a]\} + ^2]^{0.5} \qquad (6)$$

where: (h) - satellite altitude (km)
(r) - Earth's radius (km)
(a) - angle of arrival relative

In the worst case, (d_1) could correspond to a 0 degree angle of arrival and (d_2) could correspond to a 90 degree angle of arrival, i.e., equal to (h). Solution for (d_1/h) using equation (5) is closely approximated up to 20 degree angles of arrival by;

$$20 \log (d_1/h) = 10 \log (1 + 2r/h) - 7.25a/h^{0.5} \qquad \text{(dB)} \quad (7)$$

Substituting equation (6) in equation (4) along with the assumption on satellite gain results in

$$E_{MIN} \geq E_P - 15 \log[1 + 5/d] + 9 + 10 \log(1 + 2r/h) - 7.25a/h^{0.5} \qquad \text{(dBW)} \quad (8)$$

Values from equation (8) are given in table 4 for different satellite altitudes where the operational angle of arrival at the feeder link earth stations is equal to or greater than 0 degrees and 20 degrees.

Table 4 Minimum Earth Station e.i.r.p. (non-GSO case)

Elev. Angle	0^0		20^0	0^0		20^0	0^0		20^0	0^0		20^0
System/ h-km		800			1,400			2,000			10,000	
SBR	75.8		70.6	73.5		69.7	72.2		68.8	67.1		65.6
ALS_H	74.5		69.3	72.2		68.4	70.9		67.6	65.8		64.3
ALS_L	61.0		55.8	58.7		54.9	57.4		54.1	52.3		50.8
MSBLS	67.0		61.6	64.7		60.7	63.4		60.0	58.3		56.8
MPR	82.9		77.7	80.6		76.8	79.3		76.0	74.2		72.7

It is noted that there is a range of values for the ALS systems. The results in table 4 are for feeder links which use FDMA and use QPSK with 3/4 rate FEC coding. Previous measurements have indicated that about a 3 dB higher e.i.r.p. will be needed for uncoded QPSK modulation.

3.4 Minimum Earth Station e.i.r.p. for Geostationary Satellite Networks

Values of required Earth station e.i.r.p.'s may be obtained from table 3 for uncoded digital signals by adding 3 dB to the table values. It is assumed that the feeder link modulation in not more sensitive to interference than uncoded QPSK. Because of the large variations between radionavigation systems, two cases may be considered,i.e., 1) where the total band is shared and 2) where only part of the band is shared. For the first case the MPR is the limiting system and the minimum Earth station e.i.r.p. is 74 dBW for digital carrier bandwidth greater than 500 kHz. For the second case, the SBR and MPR would be in a band segment not shared with feeder links. With respect to the ALS, most of these systems operate with a peak e.i.r.p. of 64.5 dBW, which is 6.5 dB less than the highest value of 71 dBW given in table 2. Those systems exceeding 64.5 dBW might also be accommodated in the same portion of the band as the SBR and MPR. With these conditions, a portion of the band could be shared with feeder links with a minimum Earth station e.i.r.p of 59 dBW for digital carrier bandwidths greater than about three MHz. For carrier bandwidths less than three MHz, the minimum Earth station e.i.r.p. density would be 54.2 dB(W/MHz).

3.5 Minimum Earth Station e.i.r.p. For Non-Geostationary Satellite Networks

The same conditions enumerated in section 3.4 can be used for this case. Additional conditions included; 1) in order to arrive at a single value for the minimum Earth station e.i.r.p. it is assumed that the minimum operating altitude of the satellites is about 800 km and 2) minimum operating Earth station elevation angles can also be considered. The values given in table 4 are used to determine minimum Earth station e.i.r.p.'s for the various conditions. For total band sharing, the minimum Earth station e.i.r.p. is 86 dBW for carrier bandwidths greater than 500 kHz and elevation angles equal to or less than 20 degrees. For elevation angles greater than 20 degrees the value is 81 dBW. For partial band sharing, the minimum Earth station e.i.r.p. is 71 dBW for carrier bandwidths greater than three MHz and elevation angles equal to or less that 20 degrees. For elevation angles greater than 20 degrees the value is 66 dBW. For carrier bandwidths equal to or less than three MHz the minimum e.i.r.p. densities are 66 dB(W/MHz) and 61.2 dB(W/MHz) respectively. If the minimum satellite operating altitude is to be included as a variable, the correction factor for the preceding values for other altitudes is (-10 log (0.059 + 753/h)) in (dB).

3.6 Summary

The minimum Earth station e.i.r.p. densities derived in the preceding sections are summarized as follows:

Satellite Orbit	Total Band Sharing	Elevation Angle Degrees	Partial Band Sharing	Elevation Angle Degrees
Geostationary	74 dBW BW>500kHz	0	59 dBW BW>3MHz 54.2 dB(W/MHz) BW≤3MHz	0 0
Non-Geostationary	86 dBW BW>500kHz 81 dBW BW>500kHz	0 20	71 dBW BW>3MHZ 66.2 dB(W/MHz) BW≤3MHz 66 dBW BW>3MHz 61.2 dB(W/MHz) BW≤3MHz	0 0 20 20

4.0 CONCLUSIONS

4.1 Sharing of Feeder Links in the Space-toEarth Direction With the Radionavigation Service in the 15.4 - 15.7 GHz Band

The pfd limit for the surface based radars would require extremely large feeder link earth station antennas and therefor sharing is not considered feasible. The pfd limit for the airborne radars would also limit the size of feeder link earth station antennas to a minimum value which could be considered feasible for systems that do not use large numbers of earth stations. The pfd for the aircraft landing systems (-111 dB(W/m^2/MHz)) for all angles of arrival would pose no significant limit on feeder link earth station antenna size. By placing the surface based radar and airborne radar systems in a portion of the band not shared with space-to-Earth feeder links would allow the remaining portion to be shared without coordination and without significant constraints on either service.